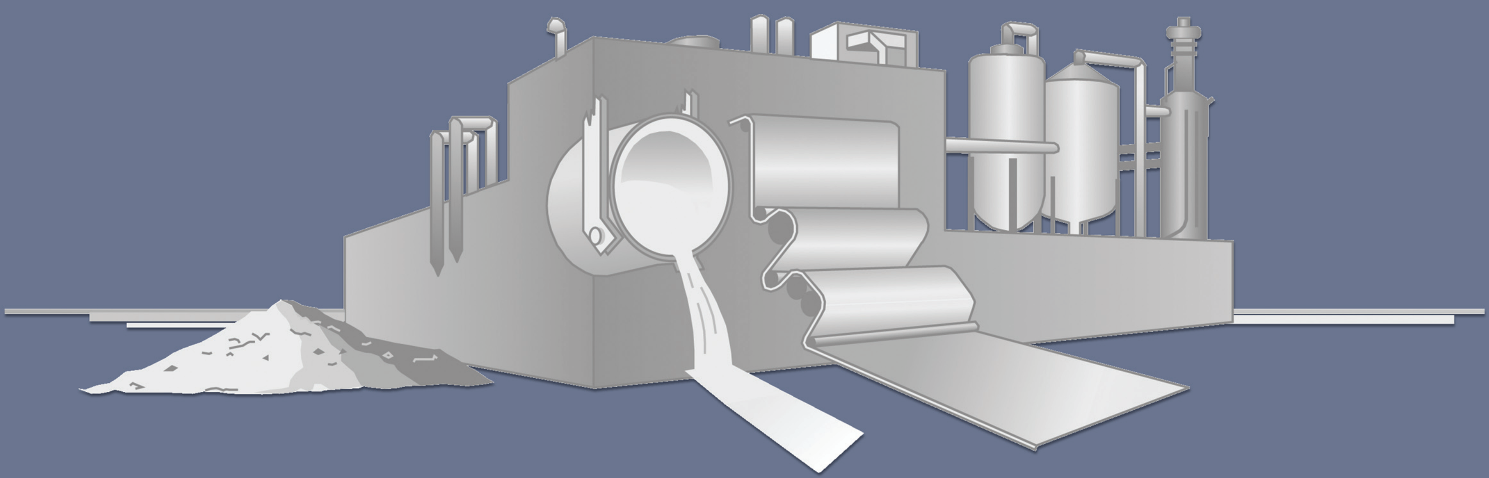
IMPACTS

February 2006

Industrial Technologies Program:
Summary of Program Results for CY 2004

Boosting the Productivity and Competitiveness of U.S. Industry



U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Foreword

Industry consumes 33% of all energy used in the United States. By developing and adopting more energy-efficiency technologies, U.S. industry can boost its productivity and competitiveness while strengthening national energy security, improving the environment, and reducing emissions linked to global climate change.

The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) works in partnership with U.S. industry to increase the efficiency of energy and materials use, both now and in the future. EERE's Industrial Technologies Program (ITP) seeks to improve the energy intensity of the U.S. industrial sector through a coordinated program of research and development (R&D), validation, and dissemination of energy-efficient technologies and operating practices. ITP develops, manages, and implements a balanced portfolio that addresses industry requirements throughout the technology development cycle. ITP's primary long-term strategy is to invest in high-risk, high-return R&D. Investments focus on technologies and practices that will provide clear public benefit but have market barriers preventing adequate private-sector investment.

ITP's efforts have resulted in over 170 technologies successfully reaching the marketplace, providing significant economic and environmental impacts for the United States. This report summarizes some of these benefits – energy savings, waste reduction, increased productivity, lowered carbon dioxide and air pollutant emissions, and improved product quality. These benefits have been tracked by periodic interviews with industrial technology suppliers and users.

We encourage you to become part of this customer-driven strategy by using energy-efficient technologies already commercially available and those beginning to emerge in the marketplace from the technology development process. We invite your comments and suggestions on this document, as well as on products and services that would help you achieve a cleaner and more competitive energy future.

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Executive Summary

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Working in partnership with industry, the U.S. Department of Energy's (DOE's) Industrial Technologies Program (ITP) is helping reduce industrial energy use, emissions, and waste while boosting productivity. Operating within the Office of Energy Efficiency and Renewable Energy (EERE), ITP conducts research, development, demonstration, and technology transfer that are producing substantial, measurable benefits to industry. This document summarizes some of the impacts of ITP's programs through 2004.

Industry is the largest and most diverse energy-consuming sector in the United States. In 2004, the industrial sector used one-third of the energy consumed in the nation. Many of the energy-intensive industries, including aluminum and steel, are limited in the choice of fuels and/or feed stocks that must be used in their processes. As a result, many opportunities for energy-efficiency improvements are very process-specific to one industry. However, because some important energy applications, such as motor drives, boilers, and compressed air systems, are common across the industrial sector, crosscutting energy-efficiency opportunities also exist.

Over the past 27 years, ITP has supported more than 600 separate research, development, and demonstration (RD&D) projects that have produced over 170 technologies. In 2004 alone, 90 successfully commercialized technologies saved 111 trillion Btu in measured savings. While these energy savings are impressive, industry has reaped even greater benefits from the productivity improvements, reduced resource consumption, decreased emissions, and enhancements to product quality associated with these technological advances. In addition, many ITP-supported projects have significantly expanded basic knowledge about complex industrial processes and have laid the foundation for developing future energy-efficient technologies.

ITP's primary role is to invest in high-risk, high-value RD&D that will reduce industry's energy requirements while stimulating economic productivity and growth. Because energy is an important input for many of the nation's key manufacturing industries, reducing energy requirements will also reduce energy costs, greenhouse gases, and other emissions and will improve productivity per unit of output. As a Federal program, ITP invests in advanced technologies that are anticipated to produce dramatic energy and environmental benefits for the nation. Investments focus on technologies and practices that will provide clear public benefit but have market barriers preventing adequate private-sector investment.

ITP has developed a six-part strategy to achieve its goals:

1. Focus on energy-intensive industries.
2. Use public-private partnerships to implement the program.
3. Identify impediments to improving industrial energy efficiency
4. Implement a balanced portfolio.
5. Perform both process-specific and crosscutting R&D.
6. Follow up with technology delivery activities to ensure efficiency improvements.

ITP tracks energy savings as well as other benefits associated with the successfully commercialized technologies resulting from its research partnerships. These benefits include current and cumulative energy savings and cumulative reductions of various air pollutants including particulates, volatile organic compounds, nitrogen oxides, sulfur oxides, and carbon.

In 2004, ITP programs were instrumental in achieving energy cost savings to industry of 366 trillion Btu and $2.06 billion. Over the entire history of ITP programs, these cumulative net benefits are about 4.72 quadrillion Btu, which is roughly equal to $23.1 billion (in 2004 dollars).

The bulk of this document consists of seven appendixes. Appendix 1 describes the 90 technologies currently available commercially, along with their applications and benefits. Appendix 2 describes the 142 ITP-supported emerging technologies that are likely to be commercialized within two or three years. Appendix 3 describes 79 ITP-sponsored technologies used in commercial applications in the past, the current benefits of which are no longer counted in this report. Appendixes 4 and 5 round out the reporting of impacts by showing the benefit of two ITP technical assistance activities: the Industrial Assessment Centers and BestPractices. Finally, Appendix 6 describes the methodology used to assess and track ITP-supported technologies.

Summary of ITP Program Impacts

Industrial Energy Use

Total energy consumption in the nation's industrial sector far exceeds any other sector and is more diverse. In 2004, the industrial sector used 33.25 quad of all types of energy (almost exactly one-third of the 99.7 quad used by the entire economy), including electricity losses of 7.69 quad (see Figure 1).

Petroleum (9.54 quad), natural gas (8.67 quad), and electricity (3.48 quad delivered) are the three fuels most used by industry, with coal and biomass providing another 3.84 quad combined. The industrial sector consumed a total of 25.56 quad, of which 21.06 quad were consumed by manufacturing industries. Of that 21.06 quad, energy-intensive industries consumed 16.60 quad. The non-energy-intensive industries (4.46 quad) and non-manufacturing industries (agriculture, mining, and construction – 4.50 quad combined) accounted for the remaining energy consumption. Industry uses nearly 7 quad of the fossil fuels for feed stocks – raw materials for plastics and chemicals – rather than as fuels. Energy expenditures in the industrial sector exceed $81 billion.

The energy-intensive industries – forest products, chemicals, petroleum refining, nonmetallic minerals (glass and cement, especially), and primary metals – account for about 75% of all industrial energy use (see Figure 2).

Many of the energy-intensive industries are limited in their choice of fuels because the technologies currently used in specific processes require a certain fuel. For example, aluminum production requires large amounts of electricity to reduce the alumina to metal. Paper pulping leaves a large residual of wood lignin that can be reprocessed for its chemical content and consequently supplies the industry with nearly half of its primary energy. Therefore, the wide variety of fuels (and feed stocks) used in the industrial sector partially reflects the specific requirements of the processes used to make specific goods or commodities. Because of specific energy requirements, the industrial sector offers a wide variety of opportunities for energy-efficiency improvements that are specific to particular industries and that crosscut many industries (i.e., are common to many industries or are needed by many process-specific technologies).

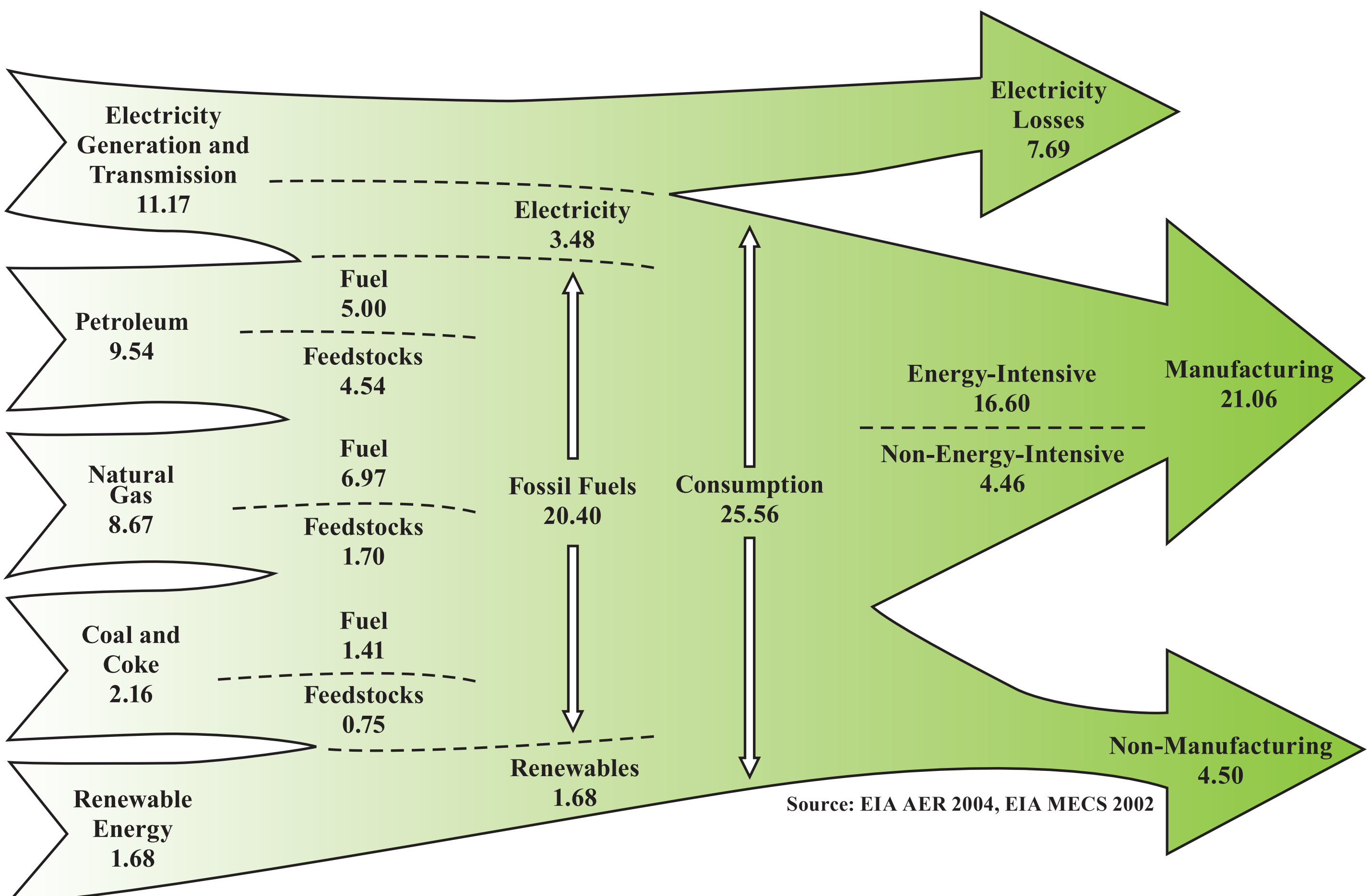

Figure 1. Industrial Energy Flows (Quad), 2004

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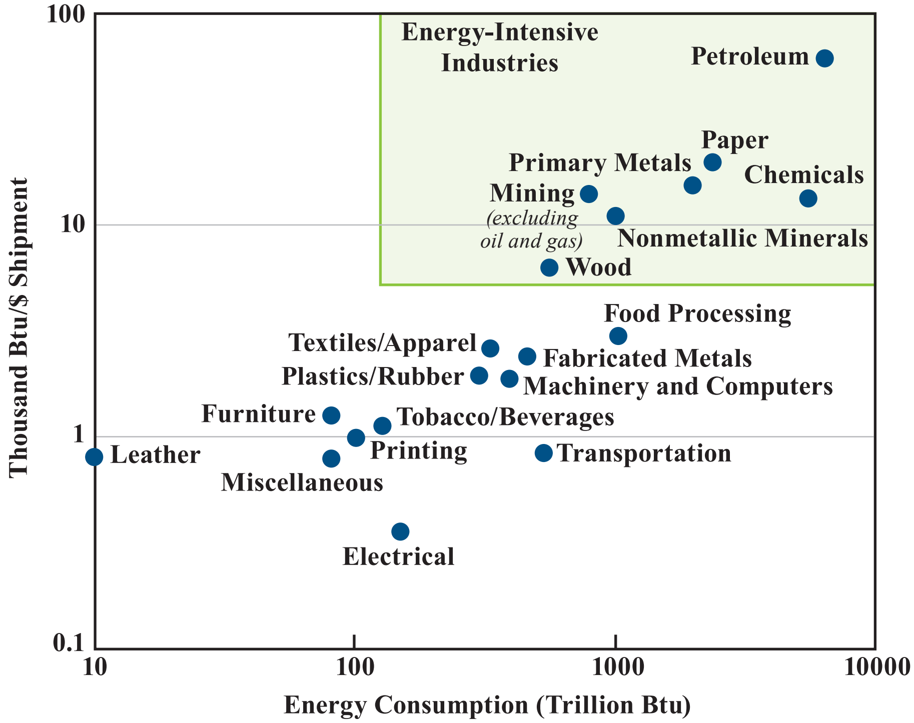
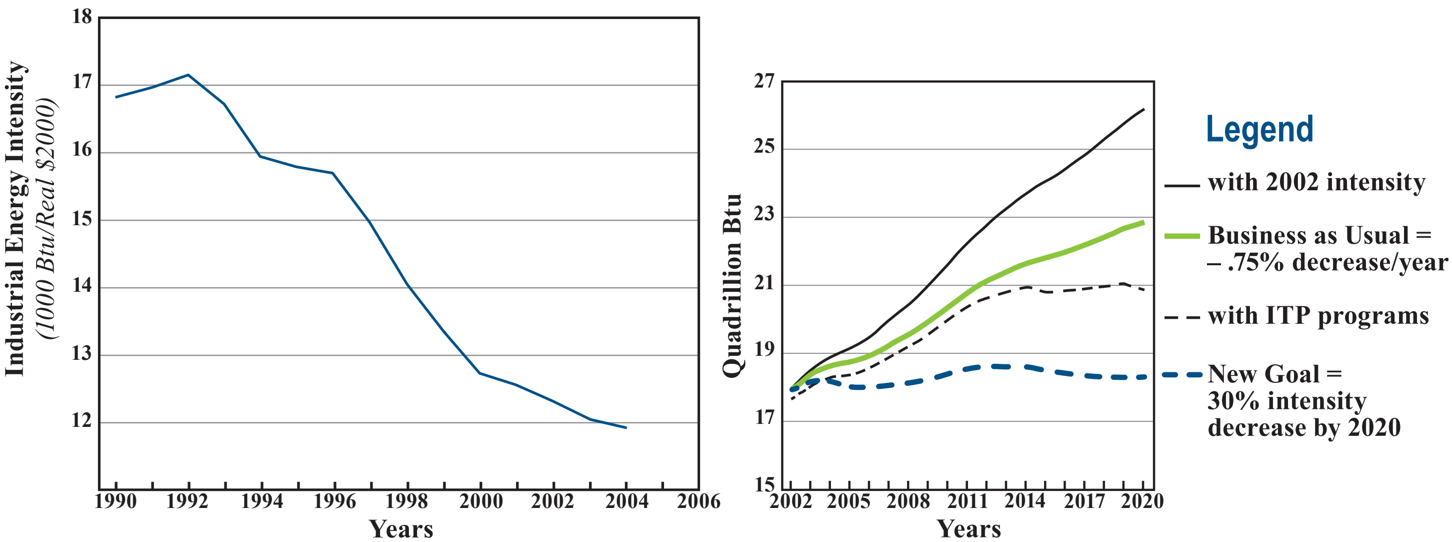


Sources: EIA MECS 2001, Bureau of Economic Analysis

Figure 2. Energy Intensity of Manufacturing Industries

The energy intensity of the industrial sector has been declining over the past decade, in part because of investments in energy-efficient technologies by the Industrial Technologies Program (ITP), previously the Office of Industrial Technologies (OIT). Since its peak in 1992, industrial sector energy intensity has declined from 17,138 Btu/dollar of industrial GDP to 11,984 Btu/dollar of real industrial sector GDP in 2004 (see Figure 3). These reductions are expected to continue into the future, as the second part of Figure 3 shows.



Sources: EIA Annual Energy Review, 2003, Table 2.1d and BEA, Value Added for Goods Producing Industries, 1990-2003, *(Constant $2000).*

Sources: EIA AEO 2004, EIA MECS 2001, ITP

Figure 3. Historical Industrial Energy Intensity and Projected Energy Use

Summary of ITP Program Impacts

The Industrial Technologies Program Office

ITP leads the Federal government's efforts to improve industrial energy efficiency and environmental performance. The program is part of the Office of Energy Efficiency and Renewable Energy (EERE) and contributes to its efforts to provide reliable, affordable, and environmentally sound energy for the nation's future.

ITP has a six-part strategy that focuses efforts on identifying the high-risk, high-payoff investments, balancing risk against rewards, and ensuring the delivery of new technologies to the marketplace:

- Focus on energy-intensive industries. A small number of energy-intensive materials and process industries account for about 75% of total industrial energy use. These industries' energy costs also are a significant portion of total costs, whereas most of manufacturing spends less than 2% of their costs on energy. ITP's Industries of the Future (IOF) process focuses on the energy-intensive industries and provides the bulk of the opportunities to improve energy efficiency.

- Use public-private partnerships to implement the program. These partnerships bring together the strengths of business and government to solve increasingly difficult and complex problems. Businesses and government work hand-in-hand to plan the collaborative research, focus on specific problems, jointly share the cost of the research, and ensure the commercialization and delivery of the research results to the cooperating parties.

- Identify impediments to improving industrial energy efficiency. Often an incremental improvement cannot overcome the major hurtles to achieving a breakthrough improvement in energy efficiency. To identify these "grand challenges," government and industry undertake analytical studies to assess the potential for improvement and then assess alternative routes, often using an entirely different process or technique to overcome impediments.

- Implement a balanced portfolio. ITP develops, manages, and implements a balanced portfolio to address the grand challenges throughout the development cycle. Three major topics are addressed: the R&D projects themselves, validation of the R&D results, and dissemination of the technologies to where they are needed to improve energy efficiency in industry.

- Perform both process-specific and crosscutting R&D. The long-term benefits from ITP's program – undertaking the high-risk, high-value research and development that will increase energy efficiency while stimulating economic productivity and growth – will only be realized if the focus is on technologies that provide clear public benefit but that would not normally be undertaken by industry. These opportunities exist both for process-specific and crosscutting technologies. The grand-challenge approach can identify the process-specific targets. Competitive solicitations help ensure that ITP is cost effective and that the best ideas are pursued.

- Follow up with technology delivery activities to ensure efficiency improvements. ITP provides a variety of assistance to ensure effective delivery of the technologies and management practices that result in industrial energy-efficiency improvements. Software toolsand training allow plants to assess their steam, compressed air, motor, pumps, insulation, and process-heating systems. Plant assessments and audits reveal inefficiencies that can lead to rapid payback investments which save both energy and money. These assessments and audits are provided to small- and medium-sized firms through the Industrial Assessment Center program and to major industrial users through a competitive solicitation process. Showcase demonstrations highlight the benefit of energy efficiency and expose managers from other companies to new and improved technologies. An extensive website library containing publications on process energy management practices helps plant managers achieve immediate savings.

In addition to these strategies, ITP partners with other program areas within EERE and performs ongoing program evaluation, including assessing past programs and the benefits that have accrued from investments.

Partnering with industry through a competitive solicitation process, the ITP provides financial assistance to selected research, development, and demonstration (RD&D) projects that can dramatically accelerate the pace of technology innovation.

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Energy-Intensive Industries

ITP focuses on a small number of energy-intensive materials and process industries that represent the biggest opportunities for energy savings and provide industry organizations for coordinating activities. Partnerships have been established with these industries and their supporting industries to improve energy efficiency:

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Steel

Crosscutting R&D targets opportunities to enable technologies that are common to many industrial processes – combustion, process heating, materials, heat treating, forging, and sensors and automation – find widespread application and yield large energy savings for even small efficiency improvements.

Technology Delivery and Best Practices

Implementing off-the-shelf technologies and energy management practices can save enormous amounts of energy. ITP funds technical assistance activities to stimulate and replicate the near-term adoption of energy-saving technologies and best practices within the industry. This collaborative effort, called BestPractices, focuses resources in four areas: software tools and training, plant assessments and audits, showcase demonstrations, and publication dissemination.

For example, Industrial Assessment Centers are one effort toward achieving the benefits of BestPractices. Teams of faculty and students from universities across the country conduct energy audits and assessments and help small- and medium-sized manufacturers identify opportunities to realize the benefits of energy-efficient technologies and practices. Figure 4 shows the location of the 26 university-based centers.

ITP is designed to achieve EERE mission objectives, operate efficiently, and encourage staff interaction. ITP's headquarters organization in Washington, D.C., is responsible for developing, managing, and evaluating technology portfolios, using strategies to best achieve ITP goals. The Golden Field Office in Golden, Colorado, and the National Energy Technology Laboratory in Pittsburgh, Pennsylvania, are responsible for initiating, managing, and monitoring ITP projects. Regional offices in Atlanta, Boston, Chicago, Denver, Philadelphia, and Seattle are responsible for delivering technologies to their many partners at the local, state, and regional level.

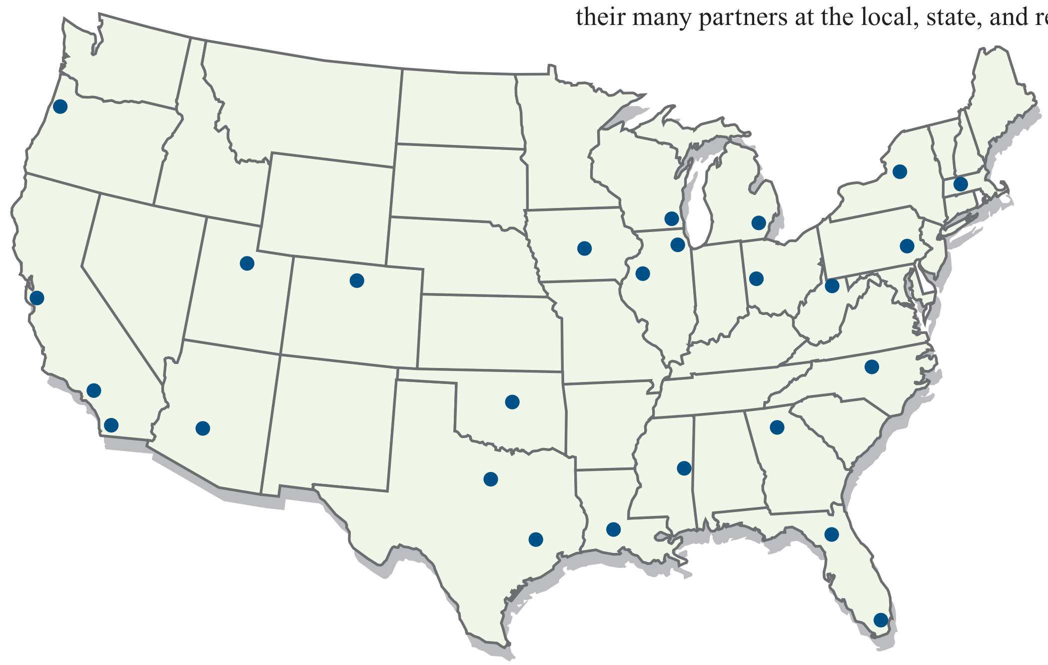

Figure 4. Locations of University-Based Industrial Assessment Centers

Summary of ITP Program Impacts

The ITP website (http://www.eere.energy.gov/industry) provides a wealth of information about the program, and the EERE Information Center (1-877-337-3463, eereic@ee. doe. gov) fields questions and facilitates access to ITP resources for industrial customers.

This report also quantifies the benefits of projects in the EERE portfolio now managed through other program offices but initiated in ITP. For example, partnerships with an emerging bio-based products industry, now managed through the Biomass Program, bring expertise and technology from several industries – agriculture, forest products, and chemicals – to create plastics, chemicals, and composite materials from renewable resources. Also, the Inventions and Innovation (I&I) Program provides grants to individual inventors and small companies for conducting early development through to prototyping for innovative energy-saving ideas. In addition, projects are included that were funded by the discontinued NICE^3 (National Industrial Competitiveness through Energy, Environment, and Economics) Program that developed and demonstrated advances in energy efficiency and clean production technologies.

Tracking Program Impacts

ITP has assessed the progress of the technologies supported by its research programs for more than 20 years. ITP managers have long recognized the importance of developing accurate data on the impacts of their programs. Such data are essential for assessing ITP's past performance and can help guide the direction of future research programs.

Energy savings associated with specific technologies are estimated by Pacific Northwest National Laboratory (PNNL) through a rigorous process for tracking and managing data. When a technology's full-scale commercial unit is operational in a commercial setting that technologyis considered commercially successful and is placed on the active tracking list. When a commercially successful technology unit has been in operation for about ten years, that particular unit is then considered a mature technology and typically is no longer actively tracked. The active tracking process involves collecting technical and market data on each commercially successful technology, including details on the following:

- Number of units sold, installed, and operating in the United States and abroad (including size and location)
- Units decommissioned since the previous year
- Energy saved
- Environmental benefits
- Improvements in quality and productivity achieved
- Any other impacts, such as employment and effects on health and safety
- Marketing issues and barriers.

Information on technologies is gathered through direct contact with either the technology's vendors or end users. These contacts provide the data needed to calculate the technology's unit energy savings, as well as the number of operating units. Therefore, unit energy savings are calculated in a unique way for each technology. Technology manufacturers or end users usually provide unit energy savings or at least enough data for a typical unit energy savings to be calculated. The total number of operating units is equal to the number of units installed minus the number of units decommissioned or classified as mature in a given year – information usually determined from sales data or end-user input. Operating units and unit energy savings can then be used to calculate total annual energy savings for the technology.

The cumulative energy savings measure includes the accumulated energy saved for all units actively tracked. These energy savings include the earlier savings from now mature and decommissioned units.

Once cumulative energy savings have been determined, long-term impacts on the environment are calculated by estimating the associated reduction of air pollutants. This calculation is based on the type of fuel saved and the pollutants typically associated with combustion of that fuel and uses assumed average emission factors.

Several factors make the tracking task challenging. Personnel turnover at developing organizations and user companies makes it difficult to identify applications. Small companies that develop a successful technology may be bought by larger firms or may assign the technology rights to a third party. As time goes on, the technologies may be incorporated into new products, applied in new industries, or even replaced by newer technologies that are derivative of the developed technology.

Program benefits documented by PNNL are conservative estimates based on technology users' and developers' testimonies. These estimates do not include either derivative effects, resulting from other new technologies that spin off of ITP technologies or the secondary benefits of the energy and cost savings accrued in the basic manufacturing industries downstream of the new technologies. Therefore, actual benefits are likely to be much higher than the numbers reported here. Nonetheless, the benefits-tracking process provides a wealth of information on the program's successes. The process of tracking these benefits is shown in Figure 5.

Summary of ITP Program Impacts

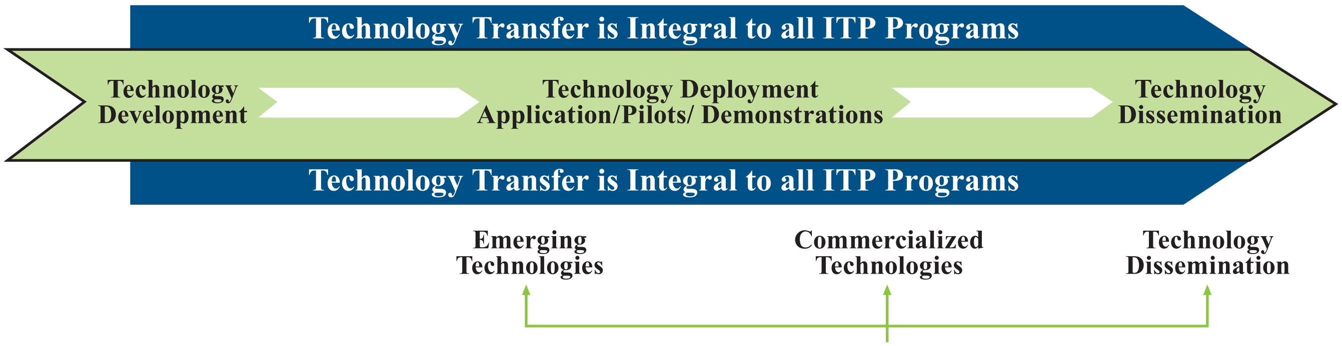

Figure 5. Technology Tracking Process

Impact Tracking System—Database

Key impact categories tracked:

- **Cumulative energy savings, current energy savings, type of fuel saved, units operating**
- **Cumulative and annual pollution reductions** *(particulates, nitrogen oxides, volatile organic compounds, sulfur dioxide, carbon dioxide)*

Over the past 27 years, ITP has supported more than 600 separate R&D projects that have produced over 170 technologies in commercial use. In 2004, there were 90 technologies that were in commercial use and yielding benefits. Appendix 1 presents fact sheets on these 90 technologies. The fact sheets include applications data, both technical and commercial, that may enable industry organizations to identify significant opportunities for adapting technologies to their particular practices. Table 1, on pages 8 and 9, provides information on the 90 currently tracked technologies. This table shows energy savings in 2004, as well as cumulative energy savings and pollution reductions. Note that for some technologies, energy savings values are unavailable, very small, or too difficult to quantify. The 90 commercial technologies saved 111 trillion Btu in 2004 and have cumulatively saved 1060 trillion Btu.

Technologies that are likely to be commercialized within two or three years are identified in Appendix 2. Some of these 142 emerging technologies have already yielded scientific information that has improved current industrial processes.

After a commercial technology has contributed to energy and cost savings for about ten years, the technology is considered historical and presumed to be supplanted by newer, more effective technologies. Appendix 3 describes the 79 historical technologies that have been used in commercial applications in the past. The technologies in this category are no longer tracked. While some may still be in use, new applications of the technologies are unlikely. During the time they were tracked, these technologies yielded benefits that are counted in the cumulative tallies shown in Table 1. The 79 historical technologies cumulatively saved 2.21 quad.

The method of calculating the results for the Industrial Assessment Centers and the resulting benefits are described in Appendix 4. As Table 1 shows, the centers saved 133 trillion Btu in 2004 and cumulatively saved 1130 trillion Btu since its inception in 1977. The method of calculating the results for the BestPractices strategy and the resulting benefits are described in Appendix 5. As also shown in Table 1, BestPractices saved 122 trillion Btu in 2004 and has cumulatively saved 322 trillion Btu since its inception in 1998.

The determination of the net economic benefits of ITP programs is discussed in Appendix 6. Using the energy savings from the technologies as well as the Industrial Assessment Centers and BestPractices, the cost savings are determined annually for the fuels saved. The annual energy savings by fuel type is multiplied by the fuel's price, with prices adjusted to reflect the fuel's current costs. The sum of all energy saved times the average energy price yields an estimate of the annual savings in that particular year. To arrive at the net economic benefits, the cumulative energy savings are reduced by the appropriation allocated by the government for ITP programs and by the cost of the industry of adopting the new technologies. Details of this methodology are provided in Appendix 6. Cumulatively, since 1976 ITP technologies and programs have saved 4.72 quad and $23.1 billion. In addition the ITP programs have cumulatively reduced emissions of carbon by 95 million tons, of nitrogen oxides by 747 thousand tons, and of sulfur dioxides by 1.47 million tons, as Table 1 shows.

Table 1. Technology Program Impacts

Technologies Commercially Available	IMPACTS Cumulative Energy Savings *(10^12 Btu)*	2004 Energy Savings *(10^12 Btu)*	Cumulative Pollution Reductions *(Thousand Tons)*				
			Particulates	VOCs	SO_X	NO_X	Carbon
Aluminum							
Aluminum Reclaimer for Foundry Applications	0.001	0.000	—	0.000	—	0.000	0.012
Aluminum Scrap Decoater	1.17	0.378	—	0.004	—	0.137	18.6
Aluminum Scrap Sorting	0.698	0.338	0.003	0.002	0.151	0.112	13.7
Detection and Removal of Molten Salts from Molten Aluminum Alloys	—	—	—	—	—	—	—
Oxygen-Enhanced Combustion for Recycled Aluminum	0.025	—	—	0.000	—	0.003	0.400
Recycling of Aluminum Dross/Saltcake Waste	9.48	2.04	0.023	0.033	1.13	1.34	170
Chemicals							
Aqueous Cleaner and CleanRinse™ Recycling System	0.119	0.015	—	0.000	—	0.014	1.88
DryWash®	0.031	0.008	0.000	0.000	0.005	0.005	0.574
Dual-Cure Photocatalyst	3.71	0.491	0.003	0.013	0.160	0.467	61.7
Micell Dry-Cleaning Technology	0.021	0.004	0.000	0.000	0.003	0.003	0.386
No-VOC Coating Products	0.004	0.001	—	0.000	—	0.001	0.070
Powder Paint Coating System	5.10	0.603	0.001	9.95	0.033	0.603	81.5
Pressure Swing Adsorption for Product Recovery	0.104	0.081	—	0.000	—	0.012	1.65
Supercritical Purification of Compounds for Combinatorial Chemical Analysis	1.21	0.466	0.005	0.004	0.261	0.195	23.8
Ultrasonic Tank Cleaning	0.040	0.005	—	0.000	—	0.005	0.640
Use of Recovered Plastics in Durable Goods Manufacturing	0.381	0.015	0.001	0.001	0.062	0.050	6.74
Water-Washed Overspray Paint Recovery	—	—	—	—	—	—	—
Forest Products							
Chemical for Increasing Wood Pulping Yield	8.08	1.09	—	0.028	—	0.946	128
Continuous Digester Control Technology	8.00	4.00	—	0.028	—	0.936	127
Detection and Control of Deposition on Pendant Tubes in Kraft Chemical Recovery Boilers	0.660	0.484	0.005	0.003	0.383	0.102	14.4
Improved Composite Tubes for Kraft Recovery Boilers	0.038	0.007	0.000	0.000	0.011	0.005	0.715
METHANE de-NOX® Reburn Process	1.16	0.218	0.003	0.003	0.168	0.180	21.7
Optimizing Tissue Paper Manufacturing	—	—	—	—	—	—	—
Pressurized Ozone/Ultrafiltration Membrane System	0.315	0.315	—	0.001	—	0.037	5.00
Thermodyne™ Evaporator – A Molded Pulp Products Dryer	—	—	—	—	—	—	—
XTREME Cleaner™ – Removal of Light and Sticky Contaminants	1.19	0.183	0.005	0.004	0.258	0.192	23.5
Glass							
Advanced Temperature Measurement System	—	—	—	—	—	—	—
High Luminosity, Low-NO_X Burner	—	—	—	—	—	—	—
Oxygen-Enriched Air-Staging *(OEAS)* Technology	—	—	—	—	—	—	—
Metal Casting							
Ceramic Composite Die for Metal Casting	—	—	—	—	—	—	—
Die Casting Copper Motor Rotors	0.091	0.085	0.000	0.000	0.020	0.015	1.78
Simple Visualization Tools for Part and Die Design	—	—	—	—	—	—	—
Mining							
Fibrous Monoliths as Wear-Resistant Components	—	—	—	—	—	—	—
Horizon Sensor™	0.169	0.072	0.001	0.001	0.036	0.027	3.32
Imaging Ahead of Mining	4.10	1.64	0.018	0.014	0.885	0.659	80.5
Smart Screening Systems for Mining	0.002	0.001	—	—	—	—	
Wireless Telemetry for Mine Monitoring and Emergency Communications	—	—	—	—	—	—	—
Steel							
Automatic High-Temperature Steel Inspection and Advice System	0.478	0.478	—	0.002	—	0.056	7.59
Dilute Oxygen Combustion System	0.042	0.007	—	0.000	—	0.005	0.667
Electrochemical Dezincing of Steel Scrap	0.030	0.017	0.000	0.000	0.019	0.008	0.831
Laser Contouring System for Refractory Lining Measurements	—	—	—	—	—	—	—
Microstructure Engineering for Hot Strip Mills	—	—	—	—	—	—	—
Recovery of Acids and Metal Salts from Pickling Liquors	0.011	0.001	—	0.000	—	0.001	0.209
Shorter Spherodizing Annealing Time for Tube/Pipe Manufacturing	0.084	0.017	—	0.000	—	0.010	1.33
Steel Reheating for Further Processing	1.00	0.154	—	0.004	—	0.117	15.9
Transfer Rolls for Steel Production	0.033	0.017	—	0.000	—	0.004	0.530

Table 1. Technology Program Impacts

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Technologies Commercially Available	Cumulative Energy Savings (10^{12} Btu)	2004 Energy Savings (10^{12} Btu)	Cumulative Pollution Reductions *(Thousand Tons)*				
			Particulates	VOCs	SO_X	NO_X	Carbon
Crosscutting							
Callidus Ultra-Blue *(CUB)* Burner	—	—	—	—	—	—	—
Catalytic Combustion	—	—	—	—	—	—	—
Chemical Vapor Deposition Optimization of Ceramic Matrix Composites	0.000	0.000	0.000	0.000	0.000	0.000	0.004
Energy-Conserving Tool for Combustion-Dependent Industries	0.004	0.002	0.000	0.000	0.001	0.001	0.077
Evaporator Fan Controller for Medium-Temperature Walk-In Refrigerators	0.054	0.016	0.000	0.000	0.012	0.009	1.06
Fiber-Optic Sensor for Industrial Process Measurement and Control	—	—	—	—	—	—	—
Fiber Sizing Sensor and Controller	—	—	—	—	—	—	—
Foamed Recyclables	—	—	—	—	—	—	—
Forced Internal Recirculation Burner	—	—	—	—	—	—	—
Freight Wing™ Aerodynamic Fairings	0.000	0.000	0.000	0.000	0.000	0.000	0.001
High-Temperature Radiant Burner	9.47	2.19	—	0.033	—	1.11	150
Improved Diesel Engines	932	82.2	6.99	4.19	542	144	20,300
Infrared Polymer Boot Heater	0.000	0.000	0.000	0.000	0.000	0.000	0.003
In-Situ, Real Time Measurement of Melt Constituents	0.259	0.222	—	0.001	—	0.030	4.11
Materials and Process Design for High Temperature Carburizing	—	—	—	—	—	—	—
Method of Constructing Insulated Foam Homes	0.033	0.005	0.000	0.000	0.002	0.004	0.560
Mobile Zone Optimized Control System for Ultra-Efficient Surface-Coating Operations	0.024	0.007	0.000	0.000	0.002	0.003	0.420
Nickel Aluminide Trays and Fixtures Used in Carburizing Heat Treating Furnaces	0.034	—	—	0.000	—	0.004	0.543
PowerGuard® Photovoltaic Roofing System	0.247	0.097	0.001	0.001	0.053	0.040	4.85
Process Particle Counter	—	—	—	—	—	—	—
Radiation-Stabilized Burner	—	—	—	—	—	—	—
Real-Time Neural Networks for Utility Boilers	57.8	11.2	0.736	0.068	36.1	15.8	1,600
RR-1 Insulating Screw Cap	0.008	0.002	0.000	0.000	0.001	0.001	0.148
Solid-State Sensors for Monitoring Hydrogen	—	—	—	—	—	—	—
SpyroCor™ Radiant Tube Heater Inserts	0.300	0.300	—	0.001	—	0.035	4.77
SuperDrive – A Hydrostatic Continuously Variable Transmission *(CVT)*	0.001	0.001	0.000	0.000	0.001	0.000	0.024
Thin Wall Casting of Stainless Steel	0.461	0.061	0.002	0.002	0.100	0.074	9.05
Ultra-Low NO_X Premixed Industrial Burner	—	—	—	—	—	—	—
Uniform Droplet Process for Production of Alloy Spheres	—	—	—	—	—	—	—
Uniformly Drying Materials Using Microwave Energy	0.107	0.030	0.000	0.000	0.004	0.013	1.77
Variable-Frequency Microwave Furnace	0.047	0.009	0.000	0.000	0.010	0.008	0.925
Waste Fluid Heat Recovery System	0.088	0.025	0.000	0.000	0.009	0.012	1.55
Waste-Minimizing Plating Barrel	3.01	0.524	0.009	0.011	0.449	0.444	55.7
Others Industries							
Absorption Heat Pump/Refrigeration Unit	2.23	0.306	0.017	0.010	1.30	0.345	48.6
Advanced Membrane Devices for Natural Gas Cleaning	—	—	—	—	—	—	—
Brick Kiln Design Using Low Thermal Mass Technology	0.248	0.032	—	0.001	—	0.029	3.94
Continuous Cascade Fermentation System for Chemical Precursors	0.814	0.037	—	—	—	—	17.2
Energy-Efficient Food Blanching	0.007	0.001	0.000	0.000	0.002	0.001	0.125
Ink Jet Printer Solvent Recovery	0.345	0.051	0.145	0.113	6.96	5.18	633
Irrigation Valve Solenoid Energy Saver	0.014	0.003	0.000	0.000	0.003	0.002	0.268
Restaurant Exhaust Ventilation Monitor/Controller	0.605	0.236	0.003	0.002	0.131	0.097	11.9
Stalk and Root Embedding Plow	0.102	0.020	—	—	—	—	2.16
Textile Finishing Process	0.136	0.023	0.000	0.000	0.013	0.019	2.38
Utilization of Corn-Based Polymers	0.033	0.018	0.000	0.000	0.019	0.005	0.723
Commercial Technologies Total	1,060	111	7.98	14.5	590	174	23,700
IAC Total	1,130	133	5.41	4.08	354	173	22,400
BestPractices Total	322	122	1.55	1.18	103	49.3	6,400
Historical Technologies Total	2,210	N/A	8.20	6.72	426	351	42,400
Grand Total	**4,720**	**366**	**23.1**	**26.5**	**1,470**	**747**	**94,900**